2.0 DATA REQUIREMENTS FOR COASTAL FLOOD HAZARD ANALYSES

To conduct a Flood Insurance Study for a coastal community, the initial effort must be to collect the wide variety of quantitative data and other site information required in ensuing analyses. This chapter describes the basic facts determining coastal flood elevations and their areal limits, including an outline for the storm expected to cause the local base flood, and characteristics of nearshore seabed through upland regions. Some data is directly input to computer models of flood effects, and other information finds application in interpreting and integrating the calculated results.

Each computer model of a separate flood effect is executed along transects, cross sections taken perpendicular to the mean shoreline to represent a segment of coast with similar characteristics. Thus, collected data are compiled primarily for transects, in turn situated on work maps at the final scale of the FIRM. Work maps are used both to locate and develop the transects, and to interpolate and delineate the flood zones and elevations.

Aside from needed quantitative information, descriptions of previous flooding and the community in general should also be collected to aid in the evaluation of flood hazards and for inclusion in the FIS text. The data collection should start at the community level and proceed by contacting county, state, and Federal agencies. Private firms specializing in topographic mapping and/or aerial photography should also be contacted, following up suggestions provided by government agencies.

2.1 Stillwater Elevations

The stillwater elevations must be determined in a rational, defensible manner, and should not include contributions from wave action either as a result of the mathematics of the predictive model, or due to the data used to calibrate the model. Only the 100-year stillwater elevation is required for the coastal analyses, although the 10-, 50-, and 500-year elevations are provided in the FIS text, and the 500-year flood boundary is mapped on the FIRM.

Stillwater elevations may be defined by statistical analysis of available tide gage records, or by calculation using a storm surge computer model. FEMA has available a self-contained hurricane storm surge model that can provide flood elevations (Reference 18), and a synthetic northeaster model that simulates the wind and pressure fields of an extratropical storm for input to a storm surge computer model (Reference 19). These computer models are used for complex shorelines where gage records are limited, nonexistent, or non-representative, and usually indicate appreciable variations in flood elevations within a community. Reference 1 specifies procedure and documentation for coastal flood studies using a storm surge model. Of particular importance here, the surge model study can provide winds and water levels over time likely with the 100-year flood.

2.2 Selected Transects

Transects should be located with careful consideration given to the physical and cultural characteristics of the land so that they will closely represent conditions in their locality. They should be placed closer together in areas of complex topography, dense development, unique flooding, and where computed wave heights and runup may be expected to vary significantly. Wider spacing may be appropriate in areas having more uniform characteristics. For example, a long stretch of undeveloped shoreline with a continuous dune or bluff having a fairly constant height and shape, and similar landward features, may only require a transect every one to two miles; whereas, a developed area with various building densities, protective structures, and vegetation cover may require a transect every 1,000 feet or so.

Good judgment exercised in placing required transects will avoid excessive interpolation of elevations between transects, while also avoiding unnecessary study effort. In areas where runup may be significant, the proper location of transects will be governed by variations in shore slope or gradient. On coasts with sand dunes, transects will be sited according to major variations in the dune geometry and the upland characteristics. In other areas where dissipation of wave heights may be most significant to the computation of flood hazards, transect location will be based on variations in land cover: buildings, vegetation, etc. A separate transect will usually be appropriate at each flood-protection structure. Areas with similar characteristics may be scattered throughout a community, so results from one transect can be applied at various locations.

Transects are located on the work map with the input data compiled on a separate sheet for each transect. The data for the transect are not taken directly along the line on the work map; they are taken from the area, or length of shoreline, to be represented by the transect so that the input data depict average characteristics of the area. Because of this, it is useful to divide the work map into transect areas for data compilation.

2.3 Topography

The topographic data must have a contour interval of 5 feet or 1.5 meters, or less. While more detailed information such as spot elevations or a smaller contour interval can be useful in the definition of the dune or bluff profile, and in the delineation of flood boundaries, it is not required. The data, usually in the form of maps, should be recent and reflect current conditions, or at a minimum, conditions at a clearly defined time. Note that transects need not be specially surveyed, unless available topographic data are unsuitable or incomplete.

If possible, the shore topography should be field-checked to note any changes due to construction, erosion, coastal engineering, etc. Any significant changes should be documented with location descriptions, drawings, and/or photographs. The community, county, and state are usually the best sources for topographic data. The U.S. Geological Survey (USGS) 7.5-minute series topographic maps should also be examined. The USGS maps may have a 5-foot contour interval, and if not, they are still often useful as a reference or base map.

2.4 Land Cover

The land-cover data include information on buildings and vegetation. Stereoscopic aerial photographs can provide the required data on structures and some of the data on vegetation. The aerial photographs must not be more than 5 years old unless they can be updated by surveys. A local, county, or state agency may have the coastline photographed on a periodic basis. They may provide photographs, or give permission to obtain them from their contractor. Because topographic maps are often developed from aerial photographs, the mapping contractor should also be contacted for data.

Aerial photographs can provide the required data on tree- and bush-type vegetation, but are only useful in identifying areas of grass-like vegetation, not specific types. National Wetland Inventory maps from the U.S. Fish and Wildlife Service and color infrared aerial photographs can provide some more specific data required for marsh plants. Ground-level photographs are also useful in providing information on plants. State offices of coastal zone management, park and wildlife management, and/or natural resources should be able to provide information. Also, local universities with coastal studies and/or Sea Grant programs should be contacted. Field surveys may be conducted in lieu of the above sources, but are more cost effective when used only to supplement or verify some of the data obtained from these sources.

2.5 Bathymetry

Bathymetric data can be acquired from National Ocean Service nautical charts, although any reliable source can be used. The bathymetry must extend far enough offshore to include the breaker location for the 100-year flood; although that depth may not be exactly known in the data collection phase, it can be assumed that a mean water depth of 40 feet will encompass all typical breaker depths. Bathymetry further offshore may also be useful in interpreting likely differences between nearshore and offshore wave conditions, necessary where offshore waves are more readily specified.

2.6 Storm Meteorology

The 100-year flood elevations represent a statistical summary, and likely do not correspond exactly with any particular storm event.

However, the meteorology of storms expected to provide approximate realizations of the base flood can be useful information in deciding recurrence intervals for historical events and in assessing wave characteristics likely associated with the 100-year flood. An important distinction is whether the 100-year flood is more likely to be caused by an extratropical storm or by a hurricane. This answer should be clearly established in the course of defining the stillwater elevations, since time history of water levels can be radically different in the two possible cases (Figure 2).

For an extratropical storm, commonly a winter storm occurring between October and Marsh, sustained winds seldom reach much above 60 mph, storm surge has relatively modest magnitude, and surge coincidence with spring high tides is usually required to attain the 100-year stillwater elevation. Extreme storms which occurred with lower tides can indicate wind and wave conditions also likely to accompany the 100-year flood. Thus, a fair amount of pertinent historical evidence may be assembled regarding expected meteorological conditions for the base flood arising from an extratropical storm. The dominant conditions include speed and duration of sustained winds, along with the storm size controlling fetch along which waves may be generated.

Where hurricanes are of primary importance, the 100-year flood is likely associated with central pressure deficits having exceedence probabilities between 5 and 10 percent (Reference 18). That

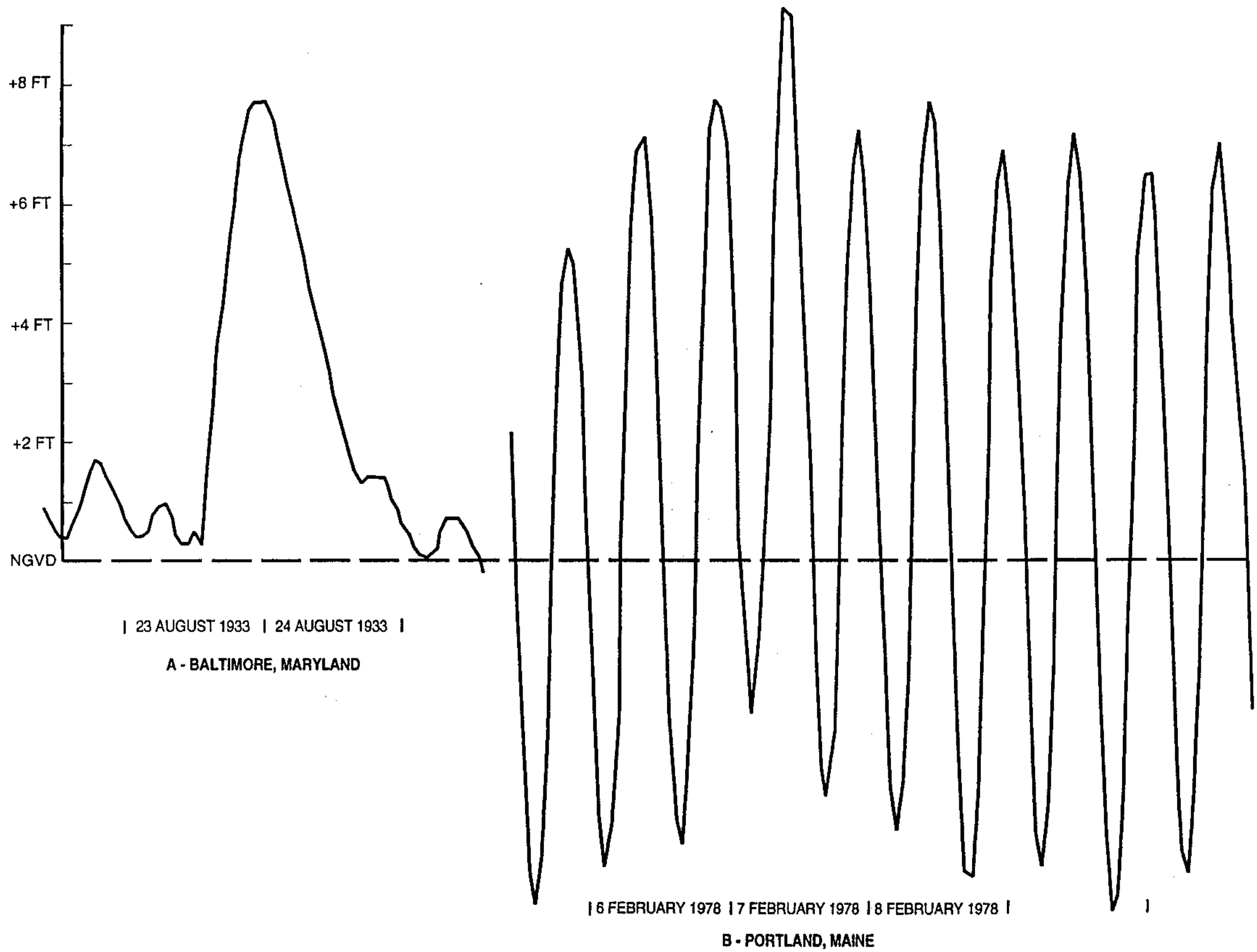

Figure 2. Gage Records of Floods Peaking Near the Local 100-Year Stillwater Elevations, Caused by, A- a Hurricane; and B- an Extratropical Storm.

description generally corresponds to a major hurricane, where sustained winds exceed 120 mph. Other meteorological characteristics are likely to be fairly typical for the study area, and may be determined using the hurricane climatology documented in Reference 20. That guidance includes localized probabilities for central pressure deficit, radius to maximum winds, and speed and direction of storm motion.

2.7 Storm Wave Characteristics

The basic presumption in conducting coastal wave analyses for an FIS is that wave direction must have some onshore component, so that wave hazards occur coincidentally with the base flood. That presumption appears generally appropriate for open coasts and along many mainland shores of large bays, where the 100-year stillwater elevation must include some contribution from direct storm surge and thus requires an onshore wind component. However, an assumption of onshore waves coincident with a flood may require detailed justification along the shores of connecting channels, in complex embayments, near inlets, and behind protective islands. Once it is confirmed that sizable waves likely travel onshore at a site during the base flood, the storm wave condition must be defined for assessments of coastal structure stability, sand dune erosion, wave runup and overtopping, and overland elevations of wave crests.

It is important to recognize that somewhat different descriptions of storm waves (Table 2) can be appropriate in assessing each distinct flooding effect. This depends mainly on the formulation of an applicable empirical or analytical treatment for each effect. In FIS models and analyses, the different wave descriptions include: various wave statistics (e.g., mean wave condition for runup elevations, but an extreme or controlling height for overland waves); various dominant parameters (e.g., incident wave height for overtopping computation, but incident wave period for overland crest elevations); and various specification sites (e.g., deep water for estimating runup elevations, but waves actually reaching a structure in shallow water for most stability or overtopping considerations). In following chapters on separate wave assessments, careful attention must be given to the stated requirements for wave description.

To proceed with general orientation, storm wave conditions may be developed from actual wave measurements, from wave hindcasts or numerical computations based on historical effects, and from specific calculations based on assumed storm meteorology. Where possible, two or all three of these possibilities should be pursued in estimating wave conditions expected to accompany the base flood at a study site. Such procedure can improve the level of certainty in estimated storm wave characteristics, by utilizing all available

Table 2. Some Commonly Used Specifications of Irregular Storm Waves.

Symbol	Name	Description
	Wave Heights (water depth must be given)	
H_s	significant	average over highest one-third of waves
H_c	controlling	defined as (1.6 H_s) in Reference 5
$\overline{H}$	mean	average over all waves
H_{mo}	zero moment	defined by the variance of water surface, and about equal to H_s in deep water
	Wave Periods (basically invariant with water depth)	
T_s	significant	associated with waves at significant height
T_p	peak	represents the maximum in energy spectrum
$\overline{T}$	mean	average over all waves

information. The following material surveys general sources for wave measurements or hindcasts, and then outlines current procedures of simplified wave estimation.

Wave measurements for many sites over various intervals have been reported primarily by the COE and by the National Data Buoy Center. Available data include records from nearshore gages in relatively shallow water (Reference 21) and from sites further offshore in moderate water depths (Reference 22). The potential sources of storm wave data also include other Federal agencies and some State or University programs.

The COE is a major source for long-term wave hindcasts along open coasts. That information is conveniently summarized as extreme wave conditions expected to recur at various intervals, for Atlantic hurricanes in Reference 23, and for extratropical storms in References 24 and 25, as examples. In some vicinities, other wave hindcasts may be available from the design activities for major coastal engineering projects.

Either measurements or hindcast results pertain to some specific (average) water depth, but such wave information may need to be converted into an equivalent condition at some other water depth for appropriate treatment of flood effects. References 12, 26, and 27 should be consulted for guidance regarding transformation of storm waves between offshore and nearshore regions, where processes to be considered include wave refraction, shoaling, and dissipation.

The other alternative in determining local storm wave conditions is to develop a specific estimate for the storm meteorology taken to correspond with the base flood. That can be done with relative ease for deep-water waves associated with a hurricane of specified meteorology, using the estimation technique provided in the Shore Protection Manual (Reference 12). For extratropical storms, a convenient PC-compatible program in the Automated Coastal Engineering System (ACES) (Reference 27) executes a modern method of wave estimation for specified water depth, incorporating some basic guidance from References 12 and 26. An outline of important considerations can assist preparations for developing a site-specific wave estimate.

Major factors in wave generation are wind speed and duration, water depth, and fetch length, the over-water distance towards the wind, along which waves arise (Reference 12). These factors determine flux of momentum and energy from the atmosphere into waves on the water surface. For some cases, fetch length might be estimated as straight-line distance in the wind direction, but current guidance (Reference 27) pertinent to many partially sheltered coastal sites indicates that a more involved analysis of restricted fetches must be performed for water basins of relatively complex geometry. The effective fetch length is derived as a weighted average of over-water distance with angle from the wind direction. With specified geometry for a restricted fetch, the cited ACES program (Reference 27) carries out computations necessary for the desired estimates of representative wave height and wave period.

The resulting wave field is commonly summarized by the significant wave height and wave period, namely, average height of the highest one-third of waves, and the corresponding time for a wave of that height to pass a point. Another useful measure is wave steepness, the ratio of wave height to wavelength: in deep water, the wave-length is 0.16 times the gravitational acceleration, times the wave period squared, that is, $(gT^2/2\pi)$. On larger water bodies and in relatively deep water, wave steepness is typically about 0.03 for extreme extratropical storms and about 0.04 for major hurricanes. These values can be used so that only a wave period or wave height may need to be determined.

2.8 Coastal Structures

Documentation gathered for each coastal structure possibly providing protection from base flood hazards should include the following:

- type and basic layout of structure
- dominant site particulars, such as local water depth, structure crest elevation, ice climate, etc.
- construction materials and present integrity

- historical record for structure, including construction date, maintenance plan, responsible party, repairs after storm episodes, etc.
- clear indications of effectiveness/ineffectiveness.

Much of this information may be developed through office activity, including a careful review of aerial photographs. In some cases of major coastal structures, site inspection could be advisable to confirm preliminary judgments.

2.9 Historical Floods

While not required as input to any of the FEMA coastal models, local information regarding previous storms and flooding can be very valuable in developing accurate assessments of coastal flood hazards. General descriptions of flooding are useful in determining what areas are subject to flooding and in obtaining an understanding of flooding patterns. More specific information, such as the location of buildings flooded and damaged by wave action, can be used to verify the results of the coastal analyses. Detailed information on pre- and post-storm beach or dune profiles is valuable in checking the results of the erosion assessment.

When quantitative data is available on historical flooding effects, special efforts should be made to acquire all recorded water elevations and wave conditions for the vicinity. That information can be used in estimating recurrence intervals for stillwater elevation and for wave action in the event, assisting an appropriate comparison to the base flood.

Local, county, and state agencies are usually good sources for historical data, especially the more recent events. It is becoming common practice for these agencies to record significant flooding with photographs, maps, and/or surveys. Some Federal agencies such as the COE, USGS, and National Research Council prepare post-storm reports for the more severe storms. Local libraries and historical societies may also be able to provide some useful data.